A NEW SPECIES OF *HALIOTIS* (MOLLUSCA) FROM THE EARLY MIOCENE BASAL WAITEMATA BEDS, RODNEY DISTRICT, NORTH AUCKLAND

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Abstract. A new species, *Haliotis (Euhaliotis) mathesonensis,* is described from the early Miocene Kawau Subgroup, Mathesons Bay, Leigh, Rodney District. It is the first *Haliotis* species from New Zealand to be assigned to the subgenus *Euhaliotis.* It is the fourth fossil haliotid to be described from New Zealand and the third from the early Miocene.

Several trips to the coastline of Mathesons Bay, Leigh, between Cape Rodney in the north and Omaha in the south have yielded many varied and unusual macrofossils. A complete crystalline shell of a large prosobranch gastropod was collected on 15 February 1996 by the author from south Mathesons Bay whilst on an Auckland Institute and Museum field trip.

GEOLOGICAL SETTING (Fig. 1)

The abrupt lithofacies transitions apparent in early Miocene basal Waitemata strata (Cape Rodney Formation, Kawau Subgroup) at Mathesons Bay are a result of regional subsidence within a volcanic interarc basin. Variable lithologies, different biotopes and associated fossils, are due to eruptive periods in the peripheral volcanics, inconsistent sediment deposition and regional tectonism (Ricketts *et al.* 1989).

Transgression occurred over an irregular Mesozoic metagreywacke bedrock surface of the Waipapa Group (Hayward & Brook 1984), producing littoral, subtidal and shallow inner shelf deposits. Initial beach sands and gravels were re-deposited into deep water to be later overlain by extensive, laterally discontinuous, turbidite flysch (Ricketts *et al.* 1989; Hayward 1993).

SYSTEMATICS

CLASS:	Gastropoda
SUBCLASS:	PROSOBRANCHIA
ORDER:	ARCHAEOGASTROPODA
SUPERFAMILY:	PLEUROTOMARIACEA
FAMILY:	HALIOTIDAE Rafinesque, 1815

GENUS:	*Haliotis* Linnaeus, 1758
Type species:	*Haliotis asinina* Linnaeus, 1758 (recent, Indo-Pacific by subsequent designation, Denys de Monfort 1810).

Shell auriform, depressed or inflated; asymmetrical with a low or pillar-raised spire situated more or less off-centre or sub-centrally posteriorly; concave ramp with spiral row of closed and open exhalant respiratory tremata along the left side; with or without rounded or flat, narrow to wide, carina at periphery; columella forming a wide, usually flat, ramp around the left side joins the basal lip, sometimes a flange; no operculum.

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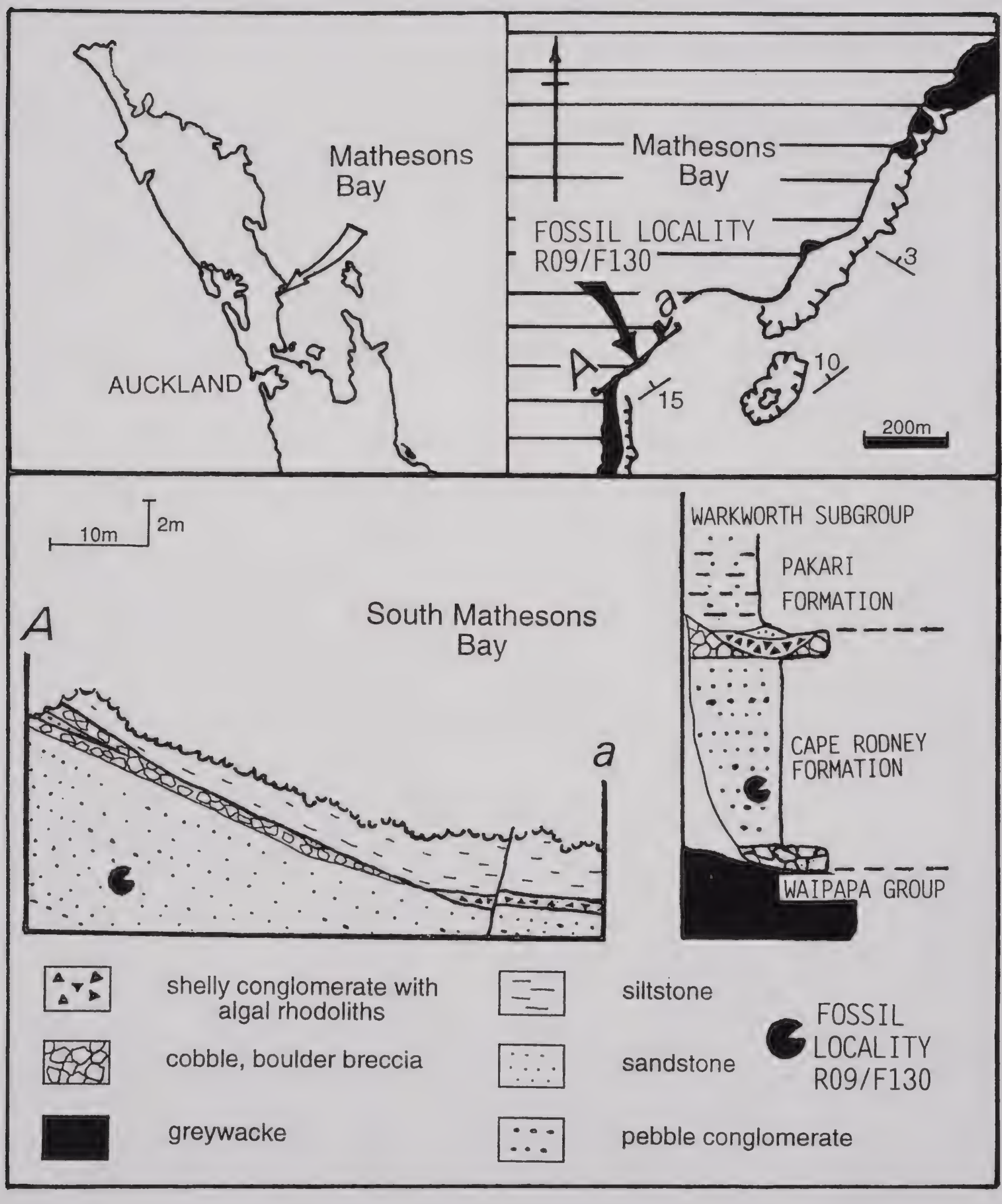


Fig. 1. Location map and geological stratigraphic column of South Mathesons Bay, Leigh, Rodney District, showing details of the early Miocene Kawau Subgroup fossil type locality R09/718428 (f130).

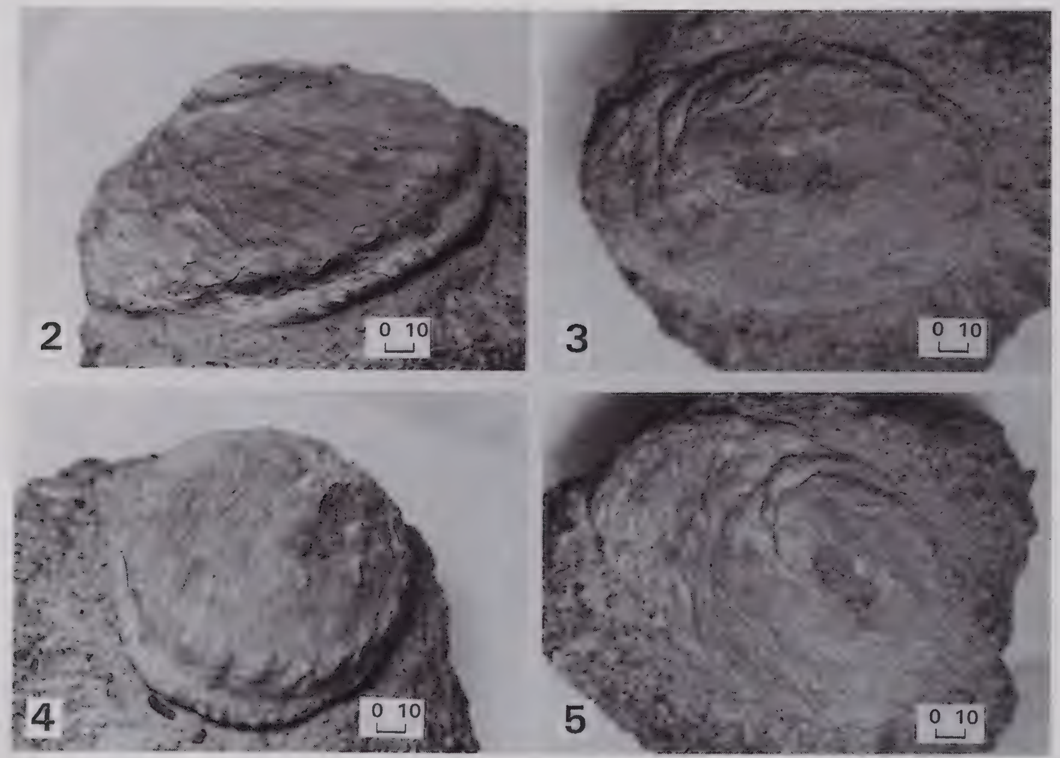
SUBGENUS: *Haliotis (Euhaliotis)* Wenz, 1938
Type species: *Haliotis midae* Linnaeus, 1758 (by original description, Recent, East Asia, South America and South Africa).

Shell elongate, ovate; tremata on tubular projections situated on angulation separating upper whorl surface from flat or concave outer face; ornament of prominent wavy transverse growth lamellae oblique to collabral lines; labial area forming a projecting flange, outer edge of which forms shell periphery; last whorl within submarginal apex.

Haliotis (Euhaliotis) mathesonensis n. sp. (Figs 2-7)

MATERIAL

Holotype. AK 72925 (Auckland Institute and Museum) collected on 15 February 1996; specimen matrix filled with crystalline calcite; shell complete except for spire.



Figs 2-5. Photographic views of the holotype of *Haliotis (Euhaliotis) mathesonensis* (AK 72925). 2. Postero-lateral. 3. Dorsal. 4. Posterior. 5. Oblique dorsal. Scale line = 10 mm.

TYPE LOCALITY

Fossil record file number RO9/f130 (Geological Society of New Zealand); grid reference R09/718 428 (1981, NZMS 260, 1:50 000 map), Mathesons Bay, Leigh, Rodney District, Auckland, New Zealand.

DESCRIPTION

Shell large, ovate, inflated; narrow, reduced columellar flange below missing apical spire; nucleus of spire remnant low, sub-central; protoconch not preserved, teleconch of about two whorls, obtusely angled below remnant spire nucleus middle; convex sutural whorl ramp joins narrow subvertical sided medial carina at the periphery; upper margin of thick outer lip, roundly notched; penultimate whorl coiled open spiral; last whorl with strong peribasal angulation; axial sculpture of well spaced, regular, prosocline plicae that become less distinct toward anterior outer lip; about 21 tremata extending from upper suture to whorl angulation on last whorl; 27+ total tremata, large, truncated conical; 11 tremata open; space between tremata concave, smooth; measurements of the holotype: diameter 136.5 mm; width 86 mm; height 85.3 mm.

The subcentral apex located midway of the shell diameter, lack of spiral cords, the large number of open tremata, vigorous growth at the anterior shell margin, possession of a thick roundly notched upper lip, no radial lirae, a reduced basal flange and a nominal axial sculpture solely of well spaced, regular, prosocline growth plicae that become less distinct toward the anterior outer lip, differentiate *H. (Euhaliotis) mathesonensis* from other fossil or Recent haliotids.

Fig. 6. Reconstruction of the shell of the holotype of *Haliotis (Euhaliotis) mathesonensis* (AK 72925).

AGE

Early Otaian (Po), early Miocene (Burdigalian).

ETYMOLOGY

Named after the type locality, Mathesons Bay.

DISCUSSION

The haliotids possess many characteristics considered by taxonomists as "primitive" (Abbott 1976; Abbott & Dance 1980). Haliotid ancestors are unknown. Some extinct taxa, such as the Triassic Temnotropidae, have auriform shells and possess haliotid-like characters. The early Mesozoic Trochotomidae also exhibit single tremata similar to the tremata characteristic of the Haliotidae today. However, it is uncertain whether a common ancestry or evolutionary convergence produced such similarities (Lindberg 1992).

Rocky shore facies and their fossils are rarely preserved due to the high energy of such biotopes (Lee *et al.* 1983; Beu *et al.* 1990; Eagle *et al.* 1995). Auriform haliotid shells are fragile. After death they are usually shattered by wave action or crushed by the tectonic effects of sediment deposition. Additionally, the aragonitic nacreous nature of the *Haliotis* shell, over time, delaminates and disintegrates. The result is a poor haliotid fossil record (Powell 1938).

Various generic and sub-generic names have been proposed for the Haliotidae. Recent *Haliotis (Euhaliotis)* have an East Asian, African, and South American distribution. *H. (Euhaliotis) mathesonensis,* although very large, solid, with whorls very rapidly increasing, is not broadly ovate, and does not have as wide a columnar flange as does the subgenus *Paua* (Fleming 1952). *H. (Euhaliotis) mathesonensis* is elongate, ovate but is not small to medium in size nor sculptured with dense spiral lirations or cords crossed by irregular transverse corrugations as are species of the subgenus *Sulculus* (Adams & Adams 1854). *H. (Euhaliotis) mathesonensis* is therefore unlike any Recent described New Zealand *Haliotis* subgenera. Although *H. (Euhaliotis) mathesonensis* has tremata on tubular projections, it cannot be assigned to the subgenus *Notohaliotis* as it does not have a raised or prominent dorsal rib or possess an ornament of spiral cords and threads crossed by irregular transverse ribs oblique to collabral lines (Cotton & Godfry 1933). Also, *H. (Euhaliotis) mathesonensis* is large, compact, orbicular-ovate in shell outline and, although having no spiral cord sculpturing, possesses body whorls that are depressed and rapidly growing, as does the subgenus *Euhaliotis* (Wenz 1938). *Haliotis* n. sp. is therefore assigned to *Euhaliotis.* This is the first record of the subgenus *H. (Euhaliotis)* for New Zealand. It has been necessary to compare a representative selection of both fossil and Recent *Haliotis* species to establish the validity of *H. (Euhaliotis) mathesonensis* as a new species. This has been undertaken on a geographic basis.

EUROPE

Because of doubtful assignation, the European Cretaceous species *Haliotis antiqua* and *Haliotis cretacea* are not compared with *Haliotis (Euhaliotis) mathesonensis.*

UNITED STATES OF AMERICA

A late Cretaceous (Maestrichtian) species, *Haliotis lomaensis* Anderson, 1902 (Fig. 8)

Figs 7-19. Drawings (dorsal view) of fossil and recent *Haliotis* for comparison with *Haliotis (Euhaliotis) mathesonensis* n. sp. (Fig. 7). Scalebar in millimetres. 7. *H. (Euhaliotis) mathesonensis*. 8. *H. lomaensis*. 9. *H. palaea*. 10. *H. lasia*. 11. *H. elsmerensis*. 12. *H. assimilis*. 13. *H. pourtalesi*. 14. *H. kamtschatkana*. 15. *H. santacruzensis*. 16. *H. kochibei*. 17. *H. kamtschatkana glabrosa*. 18. *H. kamtschatkana koyamai*. 19. *H. japonica*. [Figs 8, 15 from Durham (1979); Fig. 9 from Woodring (1931); Fig. 10 from Woodring (1932); Figs 12, 13 from Lindberg (1992); Fig. 14 after Talmadge (1963); Figs 7, 11, 16-19 by the author.]

(diameter 10 mm; width 10 mm), from Point Loma, San Diego County, California, has a slight whorl twist and a moderately well-defined spire and is similar to recent taxa. It differs from *Haliotis (Euhaliotis) mathesonensis* in having only slightly raised tremata, a wide flat basal flange, a smooth rounded medial carina and a low nucleus spire that is almost central.

All United States Miocene to Recent *Haliotis* species are from the Pacific Coast. The Californian early Miocene fossil *H. koticki* Hertlein, 1937 (diameter 102 mm; width 75 mm) differs from *H. (Euhaliotis) mathesonensis* in possessing spiral cords as well as radial lirae, the lip unites with a concave columella to form a suture which is angled, open tremata number only four, tremata form truncated-conical tubercles and the aperture is crenulate.

The holotype of the late Miocene *Haliotis palaea* Woodring, 1931 (Fig. 9) differs from *H. (Euhaliotis) mathesonensis* in being smaller (diameter 98 mm; width 70 mm), having a deep narrow groove between the exhalant tremata and shell edge, bearing an indeterminate number of open trema and having strong spiral cords intersecting crude wavy cords on the sutural ramp.

The holotype of the late Miocene *H. lasia* Woodring, 1932 (Fig. 10), from the conglomerate and sandstone Santa Margarita Formation, differs from *H. (Euhaliotis) mathesonensis* in being much smaller (diameter 75 mm; width 51.5 mm), having uniformly spaced spiral threads on the sutural ramp, having a relatively smooth shell exterior, having small, flat tremata that are not elevated (with only six open tremata) and in possessing an apical spire that is located more posteriorly.

The Pliocene *H. elsmerensis* (Fig. 11) from California is different from *H. (Euhaliotis) mathesonensis* in being larger (diameter 280 mm; width 200 mm), having only 3-4 open tremata, having a flatter sutural ramp and having the spire located subcentral posteriorly.

The Pliocene to Recent *H. assimilis* Dall, 1878 (Fig. 12) is of a similar size (diameter 130 mm) but differs from *H. (Euhaliotis) mathesonensis* in being auriform-oblong in shape, having a sinuous and undulating apertural lip, having only 4-5 open tremata and possessing a shallow groove on the external columella border.

The Pliocene to Recent *H. pourtalesi* Dall, 1881 (Fig. 13) differs from *H. (Euhaliotis) mathesonensis* in being extremely small (diameter 30 mm), having radial cords and possessing a posterior spire.

The Recent south-east Alaskan and North American *H. kamtschatkana* Jonas, 1845 (Fig. 14) although of a similar overall size (diameter 130 mm), differs from *H. (Euhaliotis) mathesonensis* in being auriform-oblong in shell outline with a particularly sinuous and undulating apertural lip. It has only four, rarely five, open tremata and possesses a shallow furrow on the external columella border.

GALÁPAGOS ISLANDS

The late Miocene fossil *H. santacruzensis* Durham, 1979 (Fig. 15) from Santa Cruz Island, Galápagos Islands, differs from *H. (Euhaliotis) mathesonensis* in having spiral cording, a distinct concave area below trematal angulation and is much smaller in size (diameter 12 mm).

NORTH-EAST ASIA

Many Miocene fossil *Haliotis* species have been described from Japan. *H. kochibei* (Fig. 16) differs from *H. (Euhaliotis) mathesonensis* by being much larger (diameter 200 mm; width 124 mm), being more elongate-ovate and having a surface sculpture of spiral lirations

Figs 20-31. Drawings (dorsal veiw) of fossil and recent *Haliotis* for comparison with *Haliotis (Euhaliotis) mathesonensis* n. sp. (Fig. 7). Scalebar in millimetres. 20. *H. diversicolor.* 21. *H. (Euhaliotis) discus.* 22. *H. (Euhaliotis) sieboldi.* 23. *H. (Notohaliotis) waitemataensis.* 24. *H. (Paua) flemingi.* 25. *H. (Sulculus) powelli.* 26. *H. (?Notohaliotis)* n. sp. 27. *H. (Paua) iris.* 28. *H. (Sulculus) australis.* 29. *H. (Sulculus) virginea virginea.* 30. *H. (Euhaliotis) midae.* 31. *H. ovina.* [Figs 25, 26 from Beu *et al.* (1990); Fig. 27 from Morton & Miller (1968); Figs 21, 22 after Smith (1967); Figs 28, 29 from Suter (1915); Figs 30, 31 from Van Nostrand (1956); Figs 20, 23, 24 by the author.]

intersected by beaded radial cords. *H. kamtschatkana glabrosa* (Fig. 17) (diameter 120 mm; width 78 mm) and *H. kamtschatkana koyamai* (Fig. 18) (diameter 104 mm; width 73 mm) are different from *H. (Euhaliotis) mathesonensis* in being more obliquely-ovate, having a low spire posteriorly, possessing low, smooth tremata, and having only four open tremata. *H. japonica* (Fig. 19) (diameter 50 mm; width 37 mm), *H. kurosakiensis*, *H. notoensis*, the Pliocene *H. gigantoides*, *H. kokei* and the Pliocene and Pleistocene *H. diversicolor* (Fig. 20) (diameter 80 mm) all differ from *H. (Euhaliotis) mathesonensis* by being of a dissimilar shell outline, having less open tremata and possessing spiral lirae on the sutural ramp.

H. (Euhaliotis) mathesonensis is similar in shape to the common Recent Japanese, Korean and North Chinese *H. (Euhaliotis) discus* Reeve, 1846 (Fig. 21) but differs in being larger, having more open tremata (*H. (Euhaliotis) discus* has only four) and in having a thick, notched, upper lip. *H. (Euhaliotis) discus* possesses a spire that is more posterior than that of *H. (Euhaliotis) mathesonensis.*

The common Recent Japanese *H. (Euhaliotis) sieboldi* Reeve, 1846 (Fig. 22) (diameter 145 mm) is more rounded in shell shape than *H. (Euhaliotis) mathesonensis,* possesses flattened radial lirae on the sutural ramp, has only six open tremata, possesses a wide thin basal lip and has an apical spire that is located almost central, low posteriorly.

NEW ZEALAND

Because of the poor record, fossil *Haliotis* are rare (Woodring 1931). Only three extinct species of haliotids have been described from New Zealand, although several more species are known from isolated, undescribed specimens, or fragmentary material ranging in age from Mangaorapan (early Eocene) to Opoitian (early Pliocene) (Beu *et al.* 1990). The described, extinct species are: *Haliotis (Notohaliotis) waitemataensis* Powell, 1938 (early Miocene - Otaian stage; Fig. 23); *Haliotis (Paua) flemingi* Powell, 1938 (early Miocene - Otaian stage; Fig. 24); and *Haliotis (Sulculus) powelli* Fleming, 1952 (Pleistocene - Castlecliffian stage; Fig. 25).

A new undescribed species of *Haliotis (?Notohaliotis)* (Beu *et al.* 1990; Fig. 26) (diameter 90 mm; width 63 mm) from the Duntroonian/Waitakian Cookson Volcanics, South Island, differs from *Haliotis (Euhaliotis) mathesonensis* in having a prominent sculpture of spiral cords marking the keel on whorl sides and traversing the sutural ramp. Consequently, *H. (Euhaliotis) mathesonensis* does not possess the short, open spines or scales where spiral cords cross the axial plicae that *H. (?Notohaliotis)* n. sp. does. The smooth, moderately wide basal flange of *H. (?Notohaliotis)* n. sp. is lacking in *H. (Euhaliotis) mathesonensis* and is replaced by a robust, roundly notched upper margin of outer lip above a much reduced basal flange that is negligible in lateral extension. *H. (Euhaliotis) mathesonensis* appears unrelated to *H. (?Notohaliotis)* n. sp.

H. (Euhaliotis) mathesonensis joins *H. (Notohaliotis) waitemataensis* and *H. (Paua) flemingi* (type locality for both: Bostaquet Bay, Kawau Island, Hauraki Gulf, North Island) as the earliest geological occurrences of *Haliotis* described from New Zealand. *H. (Notohaliotis) waitemataensis* is much smaller (diameter 56 mm; width 46 mm) than *H. (Euhaliotis) mathesonensis,* more compact, orbicular-ovate in shell outline and the body whorls are depressed to a much greater extent. The shell of *H. (Euhaliotis) waitemataensis* has strong imbricating radial folds that are fewer and weaker in *H. (Euhaliotis) mathesonensis.* There is no spiral cord sculpturing on *H. (Euhaliotis) mathesonensis* as there is on *H. (Notohaliotis) waitemataensis.* Space between the tremata and the lower margin of the shell in *H. (Notohaliotis) waitemataensis* is, unlike *H. (Euhaliotis) mathesonensis,* spirally ribbed instead of smooth. In *H. (Notohaliotis) waitemataensis,* tremata are tubular, number about 21 on the body whorl and are raised, but not as distinctly as in *H. (Euhaliotis) mathesonensis.*

H. (Paua) flemingi is also much smaller (diameter 78 mm; width 55 mm), depressed and less elongate-ovate than *H. (Euhaliotis) mathesonensis.* The irregular arcuate forwardly-directed radial folds are more frequent and more pronounced than those in *H. (Euhaliotis) mathesonensis.* The nucleus, at about one-third of the length from the left margin, is completely different from that of *H. (Euhaliotis) mathesonensis* which has a spire nucleus located subcentrally, left margin, at about half-way down the length of the holotype. The tremata are only slightly raised on *H. (Paua) flemingi* compared to the large, truncated conical tremata of *H. (Euhaliotis) mathesonensis.*

The imperfect internal cast described as *H. iris* Martyn, 1784 from Cape Rodney, North Island (Harris 1897; Suter 1913), is certainly not the Recent *H. (Paua) iris* Gmelin, 1791. The specimen, G.9549, in Sir James Hector's Collection, British Museum, could belong to any one of the three haliotids found fossil in the Otaian basal Waitemata Group lithofacies - *mathesonensis*, *waitemataensis* or *flemingi*.

The New Zealand Pliocene fossil (?Opoitian - Recent) *H. (Paua) iris* Gmelin, 1791 (Powell 1976; Fig. 27), although of similar size (diameter 117 mm; width 78 mm), is different from *H. (Euhaliotis) mathesonensis* in having a wide flat basal flange instead of a reduced, minimal one; in possessing a smooth rounded, instead of notched medial carina; in having smaller tremata that are not as raised; and in possessing a low spiral nucleus apex that is located left of centre, posteriorly and not sub-centrally, mid-length as in *H. (Euhaliotis) mathesonensis.*

H. (Euhaliotis) mathesonensis is larger, more inflated and more elongate-oval than New Zealand Pleistocene and Recent fossil species. The apex is more central than in *H. (Sulculus) australis* Gmelin, 1791 (Haweran stage - Recent; Fig. 28) (diameter 82 mm; width 73 mm), *H. (Sulculus) virginea virginea* Gmelin, 1791 (Haweran stage - Recent; Fig. 29) (diameter 50 mm; width 36 mm), *H. (Sulculus) virginea crispata* Gould, 1847 (Haweran stage - Recent), *H. (Sulculus) virginea huttoni* Filhol, 1880 (Recent) and *H. (Sulculus) virginea morioria* Powell, 1938 (Recent).

The New Zealand Pleistocene (Putikian geologic substage) fossil *H. (Sulculus) powelli* Fleming, 1952 (type locality - Ohope Beach, Whakatane, North Island), compared to *H. (Euhaliotis) mathesonensis* is much smaller (diameter 47 mm; width 30.5 mm), less inflated, possesses an extremely large, depressed last whorl instead of an inflated one, has a low spiral apex located posteriorly, not sub-centrally, has four open exhalant tremata near the narrower columnar lip and is more coarsely sculptured. Closed tremata form a spiral row of low nodes in *H. (Sulculus) powelli,* whereas *H. (Euhaliotis) mathesonensis* has 11 open tremata which are swollen truncated conical and also form a spiral row. *H. (Euhaliotis) mathesonensis* has no rounded spiral costae like *H. (Sulculus) powelli,* only prominent growth ridges. Unlike *H. (Euhaliotis) mathesonensis, H. (Sulculus) powelli* has both inner and outer lips arched gently above the plane of the mollusc's foot.

NEW CALEDONIA

An undescribed leached limestone cast of a fossil *Haliotis* sp. indet. from the early to middle Miocene (Otaian - Kapitean geological stages) of New Caledonia (University of Auckland, Geology Department Collection) differs from *H. (Euhaliotis) mathesonensis* in having the apical spire subcentral posteriorly. Because it is an internal cast, the specimen is without sufficient detail for external shell comparison.

SOUTH AFRICA

The tectonically raised Tertiary beaches of the west coast of South Africa yield molluscan fossils representative of a warm water fauna (Bardnard 1953), as are the specimens from Mathesons Bay. Pleistocene to Recent haliotids include the very large *H. (Euhaliotis) midae* Linnaeus, 1758 (Fig. 30) (diameter 170 mm; width 141 mm). *H. (Euhaliotis) midae* is distinguished from *H. (Euhaliotis) mathesonensis* by corrugations running obliquely to those of the growth lines, by being more ovate than elongate-ovate and by having a low spiral apex situated sub-centrally a quarter of the way along the specimen. Of all the haliotid species compared with *H. (Euhaliotis) mathesonensis,* the extant *H. (Euhaliotis) midae* is morphologically the most similar.

AUSTRALIA

At least 23 described Recent species (Wilson *et al.* 1993) and various fossil species (Darragh 1970) of *Haliotis* occur in Australia. All of these except *H. ovina*, however, are assigned to different subgenera and so are not compared with *H. (Euhaliotis) mathesonensis*.

H. ovina Gmelin, 1791 (Fig. 31) is different from *H. (Euhaliotis) mathesonensis* in being much smaller (diameter 40 mm), having a thin shell with a low dorsal surface, being sculptured with weak spiral striae and low rounded axial folds sometimes forming rows of nodules, having only four open tremata and having a shallow depression between the holes and the tremata and several narrow ribs near the shell margin.

ANCESTRAL ORIGINS

Phylogenetic precursors of *Haliotis* have been historically attributed to the Indo-Pacific area, however, fossil discoveries along with Recent distribution and speciation models do not support this. It is more probable that a Tethys Sea/ Panthalasia Ocean Mesozoic migratory pathway facilitated a Cenozoic Gondwanan relationship between African, American, Southern European, East Asian, Australian, and New Zealand *Haliotis* species. It is suggested that subsequent Tertiary radiation or convergence within preferred ecological niches has produced species variation and form. Morphological aspects of *H. (Euhaliotis) mathesonensis* are apparent in many other southern hemisphere species. Because of the early Miocene age of the new species, it is proposed that, along with Australian fossil species of the same age, broadcast young of *H. (Euhaliotis) mathesonensis* were paleo-distributed through time by the Antarctic circumpolar current from perhaps the late Oligocene (when unobstructed circumpolar passage originated) onwards. This process facilitated the phylogenetic radiation of *Haliotis* and influenced its Tertiary distribution.

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